

Physics 137B Section 1: Problem Set #1
Due: 5PM Friday Jan 30 in 2nd floor LeConte-Birge Cross-Over

Suggested Reading for this Week: This week's problems give you a chance to review what you learned last semester about the hydrogen atom and introduce topics on electron spin, including the Pauli Matrix representation.

- For a review of the solution to the Schrodinger Eq for the hydrogen atom, see Bransden and Joachain (B& J) section 7.5
- The Stern-Gerlach experiment is described in B& J section 1.5
- The final problem on this problem set covers material in B& J sections 6.7 and 6.8. which will be discussed in class on Monday Jan 26.

Homework Problems:

1. What is the effective Bohr radius and ground-state energy for each of the following two-particle systems?
 - (a) H^2 . a deuteron and an electron (heavy hydrogen)
 - (b) He^+ , a singly ionized helium atom
 - (c) Positronium, a bound positron and electron
 - (d) Muonium, a proton and a negative μ . The μ has a mass 207 times that of the electron.
 - (e) Two neutrons bound together by their gravitational field
2. B& J problem 7.14
3. B& J problem 7.18
4. B& J problem 1.23

5. The matrix representation of the spin operator for $\text{spin}=\frac{1}{2}$ can be related to the Pauli spin matrices $\vec{\sigma}$:

$$\vec{S} = \frac{\hbar}{2} \vec{\sigma}$$

Using the explicit form of the Pauli matrices (defined in B& J eq 6.243), show the following:

- (a) $\sigma_x^2 = \sigma_y^2 = \sigma_z^2 = 1$
- (b) The commutators of the components of S satisfy the angular momentum commutator relations $[S_i, S_j] = i\hbar \epsilon_{ijl} S_k$
- (c) The Pauli matrices *anticommute*: $\sigma_x \sigma_y + \sigma_y \sigma_x = 0$
- (d) $\text{Tr} \sigma_i = 0$
- (e) $\det \sigma_i = -1$
- (f) σ_i has eigenvalues ± 1 and thus S_i has eigenvalues $\pm \hbar/2$
- (g) $S^2 = \frac{3}{4} \hbar^2 I$ where I is the identity matrix
- (h) B& J equation 6.241